

Bp
a bit body having at least one blade thereon; and
at least one polycrystalline diamond compact cutting element disposed on the at least one blade, wherein a diameter of the at least one polycrystalline diamond compact cutting element is within a range of greater than 19.0 mm, but less than 25.0 mm, and a polycrystalline diamond layer of the at least one polycrystalline diamond compact cutting element has a thickness between 0.160 inches and 0.240 inches.--

IN THE DRAWINGS:

Please add Figures 6 and 7.

Figure 2 of the drawings has been amended to include the legend "Prior Art".

The drawings were objected to for using the same reference characters to describe different elements of the figures. The drawings have been amended to ensure that each reference number indicates a particular element.

REMARKS

Please reconsider the application in view of the above amendments and the following remarks. Applicants wish to thank the Examiner for the thorough review of the application.

Objections to Drawings

The drawings were objected to for failing to show the polycrystalline diamond layer (PDC layer), the substrate layer, and an elliptical shape cutter. Figures 6 and 7 have been added to show each of these elements. No new matter is introduced by the submission of these Figures. Support for these Figures can be found at least in paragraphs 24 and 26 of the Specification, and in the original filed claims.

Figure 2 has been amended to include the legend "Prior Art."

Marked-up copies of the drawings, indicating changes made, are attached. Withdrawal of these objections is respectfully requested.

Objections to the Claims

Claims 10 and 18 were objected to because of informalities in these claims. Claims 10 and 18 have been amended to correct these informalities. Withdrawal of these objections is respectfully requested.

Rejections under 35 U.S.C. § 102

Claims 1-2, 5-8, and 13-16 were rejected as being anticipated by U.S. Patent No. 6,302,223 B1, issued to Sinor ("the '223 patent"). Claims 1, 10, and 18 have been amended. To the extent this rejection applies to the amended claims, it is respectfully traversed. The '223 patent discloses a drill bit comprising a bit body having a blade and a polycrystalline diamond compact cutting element disposed on the blade. Two sizes of cutting elements are disclosed: 19 mm and 25 mm (Col. 7, lines 13-16).

Claims 1-2 and 5-8, as amended, include the limitation that the size of the cutting element is greater than 20 mm and less than 25 mm. Claims 13-16, as amended, include the limitation that the size of the cutting element is greater than 20 mm and the interface between the substrate and the diamond layer is non-planar. The '223 patent discloses only 19 mm and 25 mm cutting elements (Col. 7, lines 13-16). The '223 patent does not disclose cutting elements having a diameter between 20 mm and 25 mm. Furthermore, the '223 patent does not disclose a cutting element having a diameter greater than 20 mm, and also having a non-planar interface between the substrate and diamond layers.

Because the '223 patent does not disclose these limitations, either the diameter of the amended claims 1-2 and 5-8, or the combination of the diameter and the non-planar interface of the amended claims 13-16, these claims are patentably distinct over the '223 patent. Accordingly, withdrawal of this rejection is respectfully requested.

Claims 1-3, 10-11 and 18-19 were rejected as being anticipated by U.S. Patent No. 5,566,779, issued to Dennis ("the '779 patent"). To the extent this rejection applies to the amended claims, it is respectfully traversed. The '779 patent discloses an insert for a bit, the

insert having a polycrystalline diamond cutting layer (PDC layer) with extended side portions. The thickness of the PDC layer may vary from 1 mm to 4 mm (Col. 3, lines 31-32 and Fig. 1). Furthermore, the '779 patent states that such a design may be used with bits up to 20 mm in diameter (Col. 3, lines 32-34).

Claims 1-3, as amended, include the limitation that the size of the cutting element is greater than 20 mm and less than 25 mm. Claims 10-11 and 18-19, as amended, include the limitation that the size of the cutting element is greater than 20 mm and the interface between the substrate and the diamond layer is non-planar. Furthermore, each of these claims includes the limitation that the at least one cutting element is disposed on a blade. The '779 patent does not disclose a blade. Furthermore, the '779 patent discloses only cutting elements up to about 20 mm. Because the '779 patent does not disclose a bit body having a blade upon which is disposed at least one cutting element having a diameter greater than 20 mm, it cannot anticipate claims 1-3, 10-11 and 18-19 of the present invention. Withdrawal of this rejection is respectfully requested.

New claim 27 includes the limitations that the cutting element is between 19.0 mm and 25.0 mm and that the PDC layer is of a thickness between 0.160 inches and 0.240 inches. This combination is neither disclosed nor suggested by either the '223 patent or the '779 patent. Therefore, claim 27 is patentably distinct over these prior art references.

Rejections under 35 U.S.C. § 103

Claims 1-26 were rejected by the Examiner as obvious over the '223 patent. To the extent this rejection applies to the amended claims, it is respectfully traversed. The '223 patent discloses a drill bit comprising a bit body with blades, and a polycrystalline diamond compact cutting element. Two sizes of cutting elements are disclosed: 19 mm and 25 mm (Col. 7, lines 13-16).

Claims 1-9 and 18-26, as amended, include the limitation that the size of the cutting element is between 20 mm and 25 mm in diameter. Claims 10-17 include the limitation that the cutting element has a diameter of at least 20 mm and a non-planar interface between the diamond layer and the substrate layer. The '223 patent discloses only 19 mm or 25 mm cutting elements. The '223 patent does not disclose or suggest cutting elements having a diameter between 20 and

25 mm. As discussed in the disclosure of the instant application, large insert sizes have been attempted, but have largely been unsuccessful due to the inability to manage the various stresses on the PDC layer and substrate, including axial, radial and hoop stresses, that are a major cause of failure of such cutters (Paragraph 4 in the Specification).

In order to drill a specific length, a certain volume of diamond will need to be used. Having fewer large cutters on a bit instead of a larger number of small cutters will result in less surface area of cutters, thereby limiting the area on which the diamond can be disposed in the form of a diamond table. Therefore, it is necessary to provide a thicker diamond table for each cutter in order to maintain the same rate of penetration as would be achieved by a bit with smaller cutting element. Prior art bits with larger cutting elements typically have a relatively thin diamond table, resulting in higher failure rates and lower overall durability of the bit. Therefore, the use of such large element bits was uncommon.

However, because larger inserts can have larger exposure, resulting in greater cutting ability, it is desirable to have a larger size cutting element. Furthermore, because the diamond table is the part of the cutting element that does most of the work of abrading a formation, it is desirable to have a thicker diamond table that will take longer to wear and can have a greater exposure. The inability to create a thicker diamond table that could withstand greater axial, radial and hoop stresses has been a limiting factor in the creation of such larger diameter cutting elements. Therefore, it is an advantage of this invention that a larger diameter cutter can be designed that will have a larger brazeable surface area for bonding to the diamond layer, allowing for an increased diamond table thickness over prior art cutters, without increasing the deleterious effect of such stresses on the bond between the substrate layer and diamond layer (Paragraphs 24 and 25 in the Specification).

Because the '223 patent does not disclose or suggest the drill bits and cutting elements of claims 1-26, these claims are patentably distinct over this reference. Accordingly, withdrawal of this rejection is respectfully requested.

Claims 1-26 were rejected by the Examiner as obvious over the '779 patent. To the extent this rejection applies to the amended claims, it is respectfully traversed. The '779 patent discloses an insert for a bit, having a polycrystalline diamond cutting layer (PDC layer) with extended side portions. The thickness of the PDC layer may vary from 1 mm to 4 mm (Col. 3,

lines 31-32 and Fig. 1). Fig. 1 of the '799 patent demonstrates that this PDC layer is thickest around the periphery and thinner towards the center of the insert face. Furthermore, the '779 patent states that such a design may be used with bits up to 20 mm in diameter (Col. 3, lines 32-34).

The '779 patent does not disclose or suggest a cutting element having a diameter greater than 20 mm. Furthermore, the '779 patent neither discloses nor suggests a diamond table thickness between 0.160 inches and 0.240 inches. As discussed previously with regard to the '223 patent, it is an advantage of the instant invention to create a drill bit having cutting elements of larger diameter, allowing for increased exposure as well as a thicker, more wear-resistant diamond table. The increased exposure and thicker diamond table both contribute to the cutting ability and longevity of the bit. Furthermore, the '779 patent also fails to disclose or suggest a blade on which at least one cutting element is mounted. For at least these reasons, claims 1-26 are patentably distinct over the '779 patent. Accordingly, withdrawal of this rejection is respectfully requested.


New claim 27 includes the limitations that the cutting element is between 19.0 mm and 25.0 mm and that the PDC layer is of a thickness between 0.160 inches and 0.240 inches. This combination is neither disclosed nor suggested by either the '223 patent or the '779 patent. Therefore, claim 27 is patentably distinct over these prior art references.

Conclusion

Claims 1-26 have been shown to be allowable over the prior art. Applicants believe that this paper is responsive to each and every ground of rejection cited by the Examiner in the Action dated July 3, 2002, and respectfully request favorable action in the form of a Notice of Allowance. Please apply any charges not covered, or any credits, to Deposit Account 50-0591 (Reference Number 05516.088001).

Respectfully submitted,

Date: 12/26/02

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Appendix A: Marked-Up Version of Specification

Background of Invention

Field of the Invention

[0001] The invention relates generally to drill bits which have polycrystalline diamond compact ("PDC") cutters thereon. More particularly, the invention relates to drill bits having a particular diameter of PDC cutters.

Background Art

[0002] Polycrystalline diamond compact ("PDC") cutters have been used in industrial applications including rock drilling and metal machining for many years. In these applications, a compact of polycrystalline diamond (or other superhard material such as cubic boron nitride) is bonded to a substrate material, which is typically a sintered metal-carbide to form a cutting structure. A compact is a polycrystalline mass of diamonds (typically synthetic) that are bonded together to form an integral, tough, high-strength mass.

[0003] An example of a rock bit for earth formation drilling using PDC cutters is disclosed in U.S. Patent No. 5,186,268. Figures 1 and 2 from that patent show a rotary drill bit having a bit body 10. The lower face of the bit body 10 is formed with a plurality of blades [16-25] 17-25, which extend generally outwardly away from a central longitudinal axis of rotation 15 of the drill bit. A plurality of PDC cutters 26 are disposed side by side along the length of each blade. The number

of PDC cutters 26 carried by each blade may vary. The PDC cutters 26 are brazed to a stud-like carrier, which may also be formed from tungsten carbide, and is received and secured within a socket in the respective blade.

[0004] One of the major factors in determining the longevity of PDC cutters is the strength of the bond between the polycrystalline diamond layer and the sintered metal carbide substrate. For example, analyses of the failure mode for drill bits used for earth formation drilling show that in approximately one-third of the cases, bit failure or wear is caused by delamination of the diamond from the metal carbide surface. It has been previously noted that as the diameter of the PDC cutters increase, the stress on the PDC layer and the metal carbide substrate increases. Because of this, prior art bits have typically been limited to having cutters of diameters of 19 mm. PDC cutters having an cutter diameter of 25 mm or 50 mm have been attempted, but are subject to high failure rates because of the increase in shear stress accompanying the larger cutter diameter.

[0005] A PDC cutter may be formed by placing a cemented carbide substrate into the container of a press. A mixture of diamond grains or diamond grains and catalyst binder is placed atop the substrate and compressed under high pressure, high temperature conditions. In so doing, metal binder migrates from the substrate and passes through the diamond grains to promote a sintering of the diamond grains. As a result, the diamond grains become bonded to each other to form the diamond layer, and the diamond layer is subsequently bonded to the

substrate, which is typically a planar surface. The substrate is often a metal-carbide composite material, such as tungsten carbide.

[0006] The deposited diamond layer is often referred to as the “diamond table,” or “abrasive layer.” Correspondingly, the “diamond table thickness” is defined as the thickness (by industry practice usually measured in inches) of the diamond table on the substrate. Furthermore, the “exposure” (by industry practice usually measured in millimeters (“mm”)) is defined as the portion of the diameter of the cutter which extends past the blade in the direction that the bit drills. Typically, diamond table thickness is limited by the stresses on the diamond table at the interface between the diamond and the substrate. Too thick of a diamond table may result in stress that can cause the cutter to shear from the bit body, or may result in brittle failure of the diamond table. Typical prior art diamond table thicknesses range from .090 inches to .120 inches. Typical prior art exposures are less than 10.0 mm.

[0007] As stated above, many prior art PDC cutters have the diamond table bonded to a substrate having a planar layer. However, in an attempt to reduce the inherent stresses present at the PDC/metal carbide interface, several prior art systems have incorporated substrates having a non-planar geometry to form a non-planar interface. U.S. Patent No. 5,494,477 discloses such a non-planar interface. Figure 3 illustrates one embodiment of a non-planar interface. In use, as PDC cutter [10] 110 wears, wear plane 16 (which represents the surface

providing cutting action) slowly progresses towards the center of the PDC cutter [10] 110.

[0008] A second system using a non-planar interface is disclosed in U.S. Patent No. 5,662,720. In this system, the surface topography of the substrate system is altered to create an “egg-carton” appearance. This is shown in Figure 4. The use of an “egg-carton” shape allows the stress associated with the cutting to be distributed over a larger surface area, thereby reducing delamination of the diamond table from the substrate.

[0009] As stated above, the most significant problem with PDC cutters arises from the creation of internal stresses within the diamond layer itself, which can result in a fracturing of the layer. The stresses result from difference in thermal properties of the diamond and the substrate, and are distributed according to the size, geometry and physical properties of the substrate and the PDC layer. As previously explained, PDC cutter diameters have been limited to 19 mm to obviate this stress problem when used in rotary drill bits.

Summary of Invention

[0010] In one aspect, the invention includes a drill bit having a bit body including at least one blade thereon, and at least one polycrystalline diamond compact cutting element disposed on the blade. The polycrystalline diamond compact cutting element has a diameter between 19.0 mm and 25.0 mm.

[0011] In one aspect, the invention includes a drill bit having a bit body including at least one blade thereon, and at least one polycrystalline diamond compact cutting element disposed on the blade, wherein the polycrystalline diamond compact cutting element has a non-planar interface between a substrate and a diamond layer, and the polycrystalline diamond compact cutting element has a diameter between 19.0 mm and 25.0 mm.

[0012] In one aspect, the invention includes a drill bit having a bit body including at least one blade thereon, and at least one polycrystalline diamond compact cutting element disposed on the blade, wherein the polycrystalline diamond compact cutting element has an elliptical shape, and the polycrystalline diamond compact cutting element has a major axis diameter between 19.0 mm and 25.0 mm.

[0013] In one aspect, the invention includes a drill bit having a bit body including at least one blade thereon, and at least one polycrystalline diamond compact cutting element disposed on the blade. The cutting element has a non planar interface between a substrate and a diamond table thereof, and has a diameter greater than 19.0 mm.

[0014] In one aspect, the invention includes a drill bit having a bit body including at least one blade thereon, and at least one polycrystalline diamond compact cutting element disposed on the blade. The polycrystalline diamond compact

cutting element has a diamond layer with a thickness greater than 0.140 inches. In some embodiments, the diamond table thickness is between 0.14 and 0.20 inches. The polycrystalline diamond compact cutting element in some embodiments has a diameter between 19.0 mm and 25.0 mm.

[0015] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of Drawings

[0016] Figure 1 is an illustration of a prior art drill bit having PDC cutters.

[0017] Figure 2 is an illustration of a prior art drill bit having PDC cutters.

[0018] Figure 3 illustrates a cross-sectional view of a prior art PDC cutter having a non-planar interface.

[0019] Figure 4 illustrates a prior art non-planar interface used in PDC cutters.

[0020] Figure 5 illustrates one embodiment of a drill bit using a PDC cutter in accordance with the claimed invention.

[0021] Figure 6 illustrates one embodiment of a PDC cutter in accordance with the claimed invention.

[0022] Figure 7 illustrates one embodiment of a PDC cutter in accordance with the claimed invention.

Detailed Description

[0023] Figure 5 illustrates one embodiment of a drill bit in accordance with the present invention. In other embodiments, any type of drill bit may be used, as long as at least one PDC cutter is implemented with the drill bit. Thus, Figure 5 is intended only as a specific embodiment of the invention and should in no way limit the scope of the claimed invention.

[0024] It has been determined that PDC cutters having diameters greater than 19.0 mm may be used on a drill bit without substantially increasing the failure rate of the cutters. In Figure 5, a drill bit 90 having at least one PDC cutter 100 is depicted. The drill bit 90 is formed with at least one blade 91, which extends generally outwardly away from a central longitudinal axis 95 of the drill bit 90. The at least one PDC cutter 100 is disposed on the at least one blade 91. The number of blades 91 and/or cutters 100 is related to the type of rock to be drilled, and can thus be varied to meet particular rock drilling requirements. The at least one PDC cutter 100 in the present example is formed of a sintered tungsten carbide composite substrate (not shown separately in Figure 5), and a polycrystalline diamond compact (not shown separately in Figure 5). The polycrystalline diamond compact and the sintered tungsten carbide substrate may be bonded together using any method known in the art for such bonding.

[0025] In the present example, the at least one blade 91 has at least one socket or mounting pad (not shown separately), which is adapted to receive the at least one

PDC cutter **100**. In the present embodiment, the at least one PDC cutter **100** is brazed onto the at least one socket. It should be noted that the present invention relates to the structure of the PDC cutters, and no limitations should be imported from the description of the drill bits, blades, or methods of attaching these elements together. Further, references to the use of specific substrate compositions are for illustrative purposes only, and no limitation on the type of substrate used is intended. As an example, it is well known that various metal carbide compositions, in addition to tungsten carbide, may be used. In Figure 6, [The] the at least one PDC cutter **100** may have a diameter (not shown) greater than 19.0 mm. In some embodiments, where the interface **103** between the diamond table **101** and the substrate **102** is planar, preferably the diameter of the at least one cutter **100** is greater than 19.0 mm and is less than 25.0 mm. The cutter **100** diameter is more preferably in a range of between 21.0 mm and 23.0 mm. In the present example, the diameter of the cutter **100** is most preferably 22.0 mm.

[0026] Because the at least one PDC cutter **100** in this embodiment has a diameter of 22.0 mm and, thus, has a larger brazeable surface area, as compared to prior art cutters, a diamond table thickness (not shown) of at least 0.140 inches can be used, without increasing stress related failure of the PDC cutter **100**. In some embodiments, the diamond table thickness is in a range of about 0.140 to 0.240

inches. In the present embodiment, the diamond table thickness is most preferably about 0.180 inches.

[0027] Additionally, the exposure of the at least one PDC cutter **100**, which is defined as the portion of the PDC cutter diameter **100** extending beyond the at least one blade **91**, in the present embodiment is greater than 11.0 mm. This limitation applies specifically to cylindrical cutters having a round or an elliptical cross section formed in accordance with the present invention. It is well known in the art that a type of PDC cutter known as a “stud cutter” can have much larger exposure. Prior art cylindrical cutters having round or elliptical cross sections have exposures of less than 10.0 mm by comparison.

[0028] A second embodiment of the present invention, shown in Figure 7, includes PDC cutters having a substantially elliptical cross-section substrate **117** with a major axis diameter of greater than 19.0 mm and less than 25.0 mm, rather than a substantially circular cross section in the PDC cutters described above. The following description relates only to the PDC cutters themselves, but it should be understood that at least one of such cutters is included on a drill bit as described in the previous embodiments. More preferably, the elliptical cross-section cutter **116** has a major axis diameter of between 21.0 and 23.0 mm. Most preferably, the elliptical PDC cutter has a major axis diameter of 22.0 mm. Similar to the above embodiment, using a larger diameter elliptical PDC cutter allows more diamond to be deposited onto the surface of the substrate resulting in a diamond

table thickness that is preferably in a range of .140 inches to .200 inches. In addition, the exposure of the PDC cutter in some embodiments may be increased to more than 11.0 mm.

[0029] The foregoing description of substantially elliptical cross-section PDC cutters is intended to include within its scope any number of shapes which include a longest diametric dimension and a shortest diametric dimension. Accordingly, the shape of any PDC cutter according to the invention is not intended to be limited to perfect ellipse cross-section or perfect circle cross-section.

[0030] In another embodiment, a drill bit having a PDC cutter according to the present invention may have a non-planar interface between the substrate and the diamond layer thereon. One example of such a non-planar interface is described, for example, in U.S. Patent No. 5,662,720, wherein an "egg-carton" shape is formed into the substrate by a suitable cutting and etching process. The substrate surface may be, for example, a sintered metal-carbide, such as tungsten carbide as in the previous embodiments. Similarly to the above described embodiments, a diamond layer is then deposited onto the substrate. The diameter of the cutter thus formed according to this aspect of the invention is greater than 19.0 mm. The diameter range is more preferably between 21.0 mm and 23.0 mm, and most preferably 22.0 mm. The resulting PDC cutter may have a diamond table thickness of between .140 inches and .240 inches without significantly increasing

the failure rate of the cutter thus formed. A more preferable thickness is about 0.180 inches. Other non-planar interfaces may be also used, for example, the interface described in U.S. Patent No. 5,494,477.

[0031] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

Appendix B: Marked-Up Version of Claims

1. (Amended) A drill bit comprising:
a bit body having at least one blade thereon; and
at least one polycrystalline diamond compact cutting element disposed on the at least one blade, wherein a diameter of the at least one polycrystalline diamond compact cutting element is within a range of greater than [19.0 mm] 20.0 mm, but less than 25.0 mm.
10. (Amended) A drill bit comprising:
a bit body having at least one blade thereon; and
at least one polycrystalline diamond compact cutting element disposed on the at least one blade, the at least one polycrystalline diamond compact cutting element comprising:
a polycrystalline diamond layer;
substrate bonded to the polycrystalline diamond layer, an interface surface between the diamond layer and the substrate being non-planar;
[and]
wherein a diameter of the at least one polycrystalline diamond compact cutting element is greater than [19.0 mm] 20.0 mm.
18. (Amended) A drill bit comprising:
a bit body having at least one blade thereon; and
at least one polycrystalline diamond compact cutting element disposed on the at least one blade, the at least one polycrystalline diamond compact cutting element comprising:

a polycrystalline diamond layer having a thickness greater than 0.140 inches;

a substrate bonded to the polycrystalline diamond layer, an interface surface between the substrate and the diamond layer being non-planar; [and]

wherein a diameter of the at least one polycrystalline diamond compact cutting element is greater than [19.0 mm] 20.0 mm and is less than 25.0 mm.